

REMARKS

Claims 4-8 and 14 are pending in the present application. By this Amendment, the specification is amended to overcome the Examiner's objection, without adding new matter. Applicant thanks the Examiner for the courtesies extended to Applicant's representatives during the November 19, 2002 personal interview, as disclosed in the Interview Summary. The contents of the interview is incorporated herein. Applicant respectfully requests withdrawal of the rejections, and allowance of the claims.

I. The claims are patentable subject matter under 35 U.S.C. § 101

Claims 4-8 and 14 stand rejected under 35 U.S.C. § 101 due to being allegedly directed to non-statutory subject matter. More specifically, the Examiner asserts that claims 4-8 and 14 are non-statutory based on a White House National Space Policy Fact Sheet. For at least the reasons discussed herein, Applicant respectfully submits that the rejection is improper and should be withdrawn.

A. 35 U.S.C. § 101 is to be interpreted based on the claims

As discussed during the personal interview, Applicant submits that the 35 U.S.C. § 101 must be applied to the claims, and not the specification, as the focus of examination. For additional support and clarification, Applicant refers the Examiner to MPEP § 2107, which clearly requires that Examiner examine the claims under 35 U.S.C. § 101, and that each rejection must have a claimed element as its specific basis, and merely applying a rejection to the specification alone is insufficient and improper. Therefore, Applicant respectfully submits that

the portions of the Examiner's § 101 relating to subject matter not recited in the claims should be withdrawn.

For example, but not by way of limitation, the Examiner has directed Applicant to the White House document referring to use of space nuclear reactors. Applicant notes that the claims are not directed to use of space nuclear reactors, and that development thereof is not barred by the cited reference.

B. Claims 4-8 and 14 do not recite non-statutory subject matter

Applicant respectfully submits that independent claim 14, as well as dependent claims 4, 5, 7 and 8 do not recite a nuclear space reactor, as cited in the Examiner's reference of record. Therefore, Applicant respectfully requests withdrawal of the 35 U.S.C. § 101 rejection with respect to those claims.

With respect to claim 6, which recites a nuclear core, Applicant submits that public policy with respect to the claimed nuclear core is not proscribed by 35 U.S.C. § 101. Further, it is submitted that public policy supports development of the claimed subject matter for the at least the reasons discussed in greater detail below.

C. Public policy does not bar, and actually supports the features of claim 6

Applicant notes that the policy does not bar use of such space nuclear reactors, but only requires prior approval for use. As a result, Applicant submits that the use of space nuclear reactors is not against public policy, but merely requires prior approval. Further, Applicant notes that no approval is required for the development of such devices, but only for their actual implementation.

As further support of Applicant's position, the Examiner is directed to U.S. Patent Nos. 6,329,243 and 6,329,587, submitted to the Patent Office in an Information Disclosure Statement (IDS) on December 16, 2002. The aforementioned references, which use a nuclear based thermal rocket in earth orbit, were granted by the Patent Office. Applicant respectfully submits that if the Examiner's interpretation of 35 U.S.C. § 101 and the 1996 White House reference were accurate, then those patents would have been rejected under 35 U.S.C. § 101.

Additionally, in contradiction to the Examiner's position, Applicant has included a Spacenews publication, submitted in the Information Disclosure Statement attached herewith, that includes a statement from the NASA Administrator that "The single most important effort we are after this year and the years to follow is to push for power generation and propulsion programs like the Nuclear Systems Initiative." Applicant respectfully submits that this statement clearly supports Applicant's position that public policy does not proscribe Applicant's claimed invention.

Applicant also respectfully submits that requirement of an authorization does not equate to subject matter being against public policy authorization. For example, but not by way of limitation, pharmaceutical drugs require authorization from the Food and Drug Administration (FDA), which is not required to obtain a U.S. Patent. Also, while weapons and war equipment may be subjected to a Secrecy Order, the subject matter remains statutory. In other words, a particular subject matter is intrinsically statutory or not statutory, and this status does not change as a result of a government approval requirement.

Applicant also submits that the claimed invention need not be operated in Earth orbit. The submission to approval rules for the use in Earth orbit of space nuclear reactors is aiming at the protection of public safety and Earth environment. However, Applicant notes that nuclear propulsion can also be used on escape trajectories, for which it is submitted that substantially no risk of return of the nuclear reactor to Earth exists.

The United States Space Policy cited by the Examiner sets no particular limitation for nuclear reactors placed on escape trajectory. The benefits of the propulsion device of the claimed invention are in missions for which a large thrust and a large specific impulse are important, typically manned interplanetary missions, and more specifically, on the escape part of the mission trajectory.

Accordingly, the present invention can be applied to stages for propulsion in space that come in operation in interplanetary transfer orbit or starting from other planets, and which may contribute to missions, for example (but not by way of limitation), a manned Earth-to-Mars mission (see application page 1, lines 32-37). The United States Space Policy is confirmed by the numerous radioisotope generators flown by United States on an escape orbit including after 1996 (see Annex 1 from the December 16, 2002 IDS).

Finally, the United States Space Policy provides that “U.S. Government agency proposals for international cooperation involving space nuclear power systems are subject to normal interagency review procedures”. These procedures have led in the past to successful cooperation between ESA and NASA on projects using nuclear electric generators, such as the Cassini/Huygens mission. Applicant respectfully submits that if a decision is made to launch a

manned exploration mission to the planet Mars, it is possible that NASA and ESA be associated to realize this mission, and this mission may require nuclear rocket propulsion. In this matter, Applicant refers the Examiner to “Intersector Guidelines”, Section (1) of the document cited by the Examiner in this 35 U.S.C. § 101 rejection.

Accordingly, Applicant respectfully submits that based on the claimed invention and a proper interpretation of the statute based on 35 U.S.C. § 101 and the MPEP as referenced above, the 35 U.S.C. § 101 rejection should be withdrawn.

II. The claims are in proper condition under 35 U.S.C. § 112, 1st paragraph, objection to the specification

Claims 4-8 and 14 stand rejected under 35 U.S.C. § 112, 1st paragraph due to alleged lack of enablement, and the Examiner objects to the specification. For at least the reasons discussed herein, Applicant respectfully submits that the claims and specification are in proper condition under 35 U.S.C. § 112, 1st paragraph.

Applicant respectfully submits that the 35 U.S.C. § 112, 1st paragraph enablement rejection appears to be based on the Examiner’s assertion that the specification is not enabled. Applicant notes that the claims merely need to be enabled by the specification. Therefore, Applicant respectfully submits that the Examiner has gone beyond the requirements of §112, 1st paragraph, and the rejection should be withdrawn.

The pending claims are directed to a propulsion device, not to a spacecraft. Further, no value of power or specific impulse is claimed. Therefore, Applicant respectfully submits that the

35 U.S.C. § 112, 1st paragraph rejections directed to such features should be withdrawn, for at least the reasons discussed herein.

Despite the evidence provided in the application and during prosecution thereof, the Examiner asserts that the prohibitive weight of a nuclear power reactor associated with safety devices make them unsuitable for flight applications. Applicant submits that the Examiner's basis would bar to any Patent in the field, as well as development of related technology.

Since the Applicant doesn't claim a device having a particular performance as to the ratio weight/power, no burden not commensurate with the scope of the claims should be placed on Applicant. Thus, it is submitted that the Examiner should consider the provided explanations as relevant. Applicant respectfully submits that figures in the specification illustrate a particle bed reactor that is not necessary for the implementation of the invention and is not claimed.

It can be seen when reading the above-mentioned U.S. Patent No. 6,367,243, which gives no description at all of the nuclear thermal rocket, but makes reference to the Borowski article, that the Examiner apparently goes much beyond the legal requirements of 35 U.S.C. § 112, 1st paragraph in the matter of enablement.

As examples of granted U.S. patents which have met the enablement requirements of 35 U.S.C. § 112, 1st paragraph without meeting the requirements set forth by the Examiner for the present application, Applicant refers the Examiner to US 5,636,512 for a "Nuclear Rocket feed System incorporating an auxiliary power cycle" (submitted in the December 16, 2002 IDS for the Examiner's consideration). To the best of Applicant's knowledge, the device of US 5,636,512 has never flown, and all parts of that invention have never been tested together on

ground (a comprehensive test is not possible with the currently existing ground means). Still, the patent description, which contains some elements of a nature similar to the Applicant's description, has been considered as sufficient for enablement by the USPTO.

As among others, the grant of the above-referenced U.S. Patents clearly demonstrates the level of enablement generally required in this technical field, as related to the claims of those references. For the present application, the description goes beyond what is encountered in either of the two above-mentioned patents.

Such a discrepancy of treatment between applications is not understandable and inevitably raises the question of the proper standard of requirement. Below, the Applicant summarizes the enablement of the invention based on the Patent description and on the related art, and provides additional clarification to the Examiner.

A. NUCLEAR CORE

As noted above, only claim 6 recites a nuclear core. Therefore, the rejection based on 35 U.S.C. § 112, 1st paragraph as applied to the nuclear core is only directed to claim 6. In the context of claim 6, Applicant provides the Examiner with the following additional support for its enablement.

Heating of a gas flow by a nuclear core has been demonstrated experimentally by the NERVA ground experiment at a level of power, temperature and mass flow rate comparable to the conditions to be encountered in the applications sought by the invention. The results of the actual NERVA-1 testing were obtained with the technology available about 40 years ago and are considered to be related art, as discussed in the previous response. Among the disclosed results

was the explanation of the value of 0.2 MW/kg, which is accepted in the technical field of the present invention since the NERVA program was fulfilled nearly 40 years ago.

However, to reduce the weight, the preferred embodiment contemplated by inventor and according to his best knowledge has been enabled as required by § 112. It is a particle bed reactor design, but this preferred embodiment is not the only possible embodiment of the claimed invention. Significantly, there is no claim that is specifically directed to such a reactor, and therefore, should not serve as a basis for the rejection, especially since as mentioned in the specification, a conventional reactor may be used even if the weight will be higher, but is by no way prohibitive as the Examiner contends, in spite of the evidences and figures that have been provided.

Even if the Examiner maintains his §112, 1st paragraph enablement rejection, Applicant respectfully submits that the design of a particle bed reactor has been considered by the U.S. Patent Office as enabled in the following U.S. Patents : 3,992,258, 3,928,638, and more particularly 4,759,911 (submitted in the December 16, 2002 IDS).

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6 More specifically, the present application discloses particle bed reactors having a mass ratio of 0.3-0.5 MW/kg and a core temperature of 3000 K. The conservative figures cited in the specification are even obtainable with conventional reactors as the NERVA- 1 engine dating back to the 1960's. Applicant respectfully submits that it is clear that the figures are given in the present application are conservative and not speculative, thus avoiding the use of figures of a speculative nature for enablement. These figures represent the inventor's best knowledge on the subject, precisely as required by § 112.

The Examiner also points out that no nuclear rocket propulsion device according to the Borowski design has yet been tested in space operation. Such proof of feasibility of nuclear powered rockets goes beyond the legal requirements for the enablement of a Patent (see US 6,367,243 to NASA, which also cites Borowski as a basis for enablement), for the claimed invention.

B. BRAYTON CYCLE

Applicant submits that the hydrogen part of the circuit in the claimed invention is enabled on the same basis as for the aforementioned U.S. patents. The same gas heating process also applies to helium, even if the thermodynamic properties of helium are slightly different from those of hydrogen. Further, it is submitted that heating helium is even easier when considering its absence of chemical reactivity and of metal fragilisation effects. Furthermore, the U.S. Patent Office already considered that the heat exchange technology from a nuclear core to a helium flow is enabled since it issued US 4,756,873, especially US 4,759,911, relates to a gas cooled particle bed reactor for multi megawatt space power and propulsion applications (see col. 1, lines 10-15).

The generation of mechanical power in a BRAYTON gas cycle is common knowledge. which does not require additional enablement for its principle. This can be found in general thermodynamics textbooks. Its application in a space environment, combined with a nuclear power reactor (as only recited in claim 6), has already been described and enabled in U.S. Patent 5,636,512 (see col. 2, lines 25-27). Its application for high power electrical generation has been

described in the U.S. patent 4,756,873, which features a thermodynamic cycle using helium and identical in principle to the Brayton cycle.

As previously explained, the capacity to reach a compression ratio of 82.2 is not speculative. The Examiner recognizes the reality of the Space Shuttle Main Engine turbopump, which delivers a pressure of 426 bar. However, the Examiner considers the example not relevant, because turbopump is not part of a Brayton cycle. The Applicant draws the attention of the Examiner to the fact that the capability of a pump to deliver a certain mass flow of a gas at a given pressure does not depend on whether that pump is part of a Brayton cycle.

The Examiner also contends that the Application does not enable a flight capable exchanger operating at temperatures higher than 20000K and at high pressure. However, in table 5.2 of the CINNAMON document cited concerning the NERVA-1 program, it was already known in the 1960s to heat a gas of low molecular weight (H₂) at high temperature (25000K) and high pressure (1000 psi or 67 bars), in a nuclear power reactor of 1520 MW (the structure of the NERVA-1 rocket is shown in figure 14.6 of the SUTTON reference provided by the Examiner). Note also that the power/weight ratio of this NERVA-1 engine was 0.19 MW/kg.

In 1992, for most of the motor components, CINNAMON mentions that the technology readiness was 5 or 6.6, corresponding to a level immediately preceding a flight engine. Conversely, the purpose of SUTTON is to give prospective figures for future development, not to give actual figures for prior art, whereas CINNAMON gives actual figures for the experimental NERVA-1 engine. Note also that US 5,636,512 considers heating the hydrogen at temperatures typically in excess of 4000 F (> 2200 C) and withdrawing heat with an heat

exchanger (recuperator 20) (see column 4, lines 46-48), so this type of technology is to be considered as well established in the related art.

The heating of a gas of low molecular weight only by heat transfer from a nuclear reactor has been demonstrated in the previous paragraphs. Hence, the state of the art teaches how to produce helium at 2000 K and at the appropriate pressure. The fact that helium is a noble gas is an advantage since it cannot react chemically with the engine.

Additionally, the Examiner strongly disagrees with the statement p. 6, lines 6-7 of the reply to his comments dated January 27, 2000 : "The manner in which heat is generated is not material to the operation of the heat engine". If the Examiner reads once again the paragraph in which this sentence is written, he will immediately recognize that this sentence refers to steam engines. The sentence means that the thermodynamic cycle for a steam engine does not depend on whether the heater for a steam engine is a coal furnace or a gas heater.

C. GENERATION OF ELECTRICAL POWER

In the objection, the Examiner questions the frequency of the electrical power to be generated as compared to the estimated speed of rotation of the turbopump. Applicant has provided hereafter further complementary information on one of the preferred variant for the design of the alternator according to the invention.

The usual speed of rotation for a turbopump is of the order of 30,000 revolutions per minute. The direct use of an alternator on a shaft rotating at this speed provides power at a frequency, which is a multiple of 500 Hertz, the multiplier depending on the number of poles of the alternator. With 20 poles, the frequency of the power output can be obtained at 5 kHz. A

frequency multiplication by a factor 12 would therefore be required to obtain the order of magnitude of 60 kHz, which may be obtained in a simple way (i.e., by electronic conversion of frequency). The drawbacks of industrial converters disclosed in the patent description (i.e., poor efficiency and heavy weight) do not apply to this conversion, because in the case of industrial application the power to be converted is provided at 50 Hz, whereas in the case of the invention the power at the exit of the alternator coils is at a multiple of 500 Hz (e.g., at 5 kHz). To obtain 60 kHz. the multiplication factor is 12 (and a much better efficiency) instead of 1200 for conventional conventions of poor efficiency. The higher the multiplication factor, the lower the efficiency.

As described in the invention, the alternator is cooled at cryogenic temperature. This makes also losses much lower as compared to usual industrial applications. In industrial applications, where the power is initially provided at 50 Hz, it is known that frequency converters present a large amount of mass and also suffer from the drawback of poor energy efficiency when designed for an industrial induction heating system. The general idea of the text was the avoidance of a complicated frequency converter and not the avoidance of any converter.

For a better understanding, Applicant has amended the specification to more clearly disclose this concept. Thus, Applicant respectfully requests withdrawal of the rejection, and allowance of the claims.

III. The claims are novel under 35 U.S.C. § 102(b)

Claim 14 stands rejected due to alleged anticipation under 35 U.S.C. § 102(b) over Curtiss et al. (U.S. Patent No. 3,173,248, hereafter "Curtiss"). Applicant respectfully submits that

Curtiss fails to disclose all of the claimed combination of features, as required for an anticipation rejection under §102. For at least the reasons herein, Applicant respectfully requests withdrawal of the rejections, and allowance of the claims.

Instead of applying Dailey (US 5 170 623), the Examiner rejects new claim 14 over Curtiss with the idea that the alternating current in coil 12 inherently heats the ejected gases. Like Dailey, Curtiss uses Lorentz forces to generate thrust, namely magnetohydrodynamic propulsion. For this, the plasma must be brought at high temperature to be ionized to develop Lorentz forces.

In the Applicant's claimed invention, the gas in the nozzle is heated by induction, and then heat is converted into additional thrust by thermal expansion in a downstream part of the nozzle. Accordingly, the gas velocity at the exit of the downstream nozzle is much higher than the velocity at the exit of the induction coil, due to this thermal expansion, which creates additional thrust.

In Curtiss, the propulsion is of magnetohydrodynamic nature. The exit of the coil is the exit of the Curtiss engine. Therefore, the velocity of the gas at the exit of the coil is the velocity of the gas at the exit of the Curtiss engine. This is obvious from the figure 1 of Curtiss: there is no nozzle downstream of the coil, which is an essential difference with the claimed invention.

The absence of the downstream nozzle demonstrates that Curtiss harnesses a mode of propulsion which is fundamentally different to the one used by applicant's invention, namely a magnetohydrodynamic propulsion i.e. the use of Lorentz forces) instead of a thermal expansion

propulsion (i.e. the transformation by a nozzle of the thermal energy of a gas into translational energy of this gas).

Applicant also submits that in Curtiss, the power source is pulsed according to a duty cycle (“On” for 1 millisecond and “Off” for 9 milliseconds), which is mandatory for this type of propulsion (see Dailey column 5, lines 8 —26 and figure 3 and more particularly column 5, lines 12 -14: “with a symmetrical current waveform, no net thrust would be generated, since forward thrust would equal reverse thrust”).

Conversely, according to the claimed invention as recited in independent claim 14, the power is transformed into heat by induction and said heat generates the thrust, which is not the case in Curtiss. Therefore, Applicant respectfully requests withdrawal of the anticipation rejection, and allowance of claim 14.

IV. The claims would not have been obvious under 35 U.S.C. § 103(a)

Claims 4 and 5 stand rejected due to alleged obviousness under 35 U.S.C. § 103(a) over Curtiss in view of Oberly (U.S. Patent No. 4,739,200), and claims 6-8 also stand rejected under § 103 over Curtiss and Oberly in view of Applicant’s background art (hereafter “background art”). Applicant respectfully submits that the proposed combination of references fails to disclose or suggest all of the claimed combinations of features, as required for a prima facie obviousness rejection under §103. For at least the reasons herein, Applicant respectfully requests withdrawal of the §103 rejection, and allowance of the claims.

Claims 4-8 depend from independent claim 14. Applicant respectfully submits that the dependent claims are allowable for at least the same reasons as independent claim 14, from

which they depend. Additionally, Applicant respectfully submits that claims 4-8 are also allowable for at least the additional reasons discussed in greater detail below.

The Examiner asserts that for claim 4, “it would have been obvious to one of the ordinary skill in the art at the time of the claimed invention to cool the Curtiss generator with a propellant fluid as taught by Oberly”.

A fundamental feature of the cooling fluid used by Oberly is to be cryogenic. This feature is absolutely necessary to minimize the ohmic heat loss in the electric generator. On the contrary, Curtiss teaches that the propellant gas provided at the entry of the funnel must be ionisable. Applicant respectfully submits that one skilled in the art could have easily deduced that the gas temperature will be high at the entry of Curtiss apparatus, for it to be ionized. Applicant does not find possible to reconcile both constraints of the references, and thus, the references are believed to teach away from one another, which is improper for a §103 combination. Further, the Examiner’s assertion that liquid hydrogen/liquid oxygen propellants are conventionally used in rockets does not help to solve the above contradiction. Applicant respectfully requests withdrawal of the improper §103 rejections.

The Examiner rejects claim 5, which relates to the use of additional combustion upstream of the coils, again on the basis of Curtiss and Oberly. Applicant respectfully disagrees, since he does not see any chemical reaction in Curtiss, while in Oberly the liquid hydrogen/oxygen combustion is only used to drive a turbine, which powers the alternator, and not to generate any thrust. Applicant submits that in the claimed invention, the combustion only increases the thrust,

and the generator is powered only through a BRAYTON cycle using the nuclear core as heat source.

The Examiner rejects claims 6-8 on the basis of Curtiss (Applicant has explained above why he disagrees with the Examiner's position) and on the basis of the fact that following the NERVA program, nuclear cores were state of the art for space propulsion applications. This basis for rejection contradicts previous statements of the Examiner which considers that "the NERVA program never produced a flight able engine", and more generally "the prohibitive weight of nuclear reactors and the associated safety devices makes them unsuitable for flight application". Applicant submits that the Examiner's assertions are not related to the object of the claims 6-8, reciting a thermodynamic cycle provided for the thermal engine, which mechanically powers the alternator and pumps, and for the propellant itself. Further, the fact that heat pumps and heat exchangers are state of the art does not modify the pertinence of the argument.

Therefore, Applicant respectfully requests withdrawal of the rejection, and allowance of the claims.

V. Conclusion

In view of the above, reconsideration and allowance of this application are now believed to be in order, and such actions are hereby solicited. If any points remain in issue which the Examiner feels may be best resolved through a personal or telephone interview, the Examiner is kindly requested to contact the undersigned at the telephone number listed below.

AMENDMENT UNDER 37 C.F.R. § 1.111
USSN 09/492,749

The USPTO is directed and authorized to charge all required fees, except for the Issue Fee and the Publication Fee, to Deposit Account No. 19-4880. Please also credit any overpayments to said Deposit Account.

Respectfully submitted,



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PATENT TRADEMARK OFFICE

Date: December 30, 2002

APPENDIX

VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE SPECIFICATION:

The specification is changed as follows:

Please amend the paragraph bridging pages 13 and 14:

A speed of rotation of 30,000 revolutions per minute (rpm), which is representative of the normal speed of rotation of a turbopump, makes it possible to produce electricity at a high frequency and reach a frequency having the same order of magnitude as that required without requiring the presence of a complicated frequency converter from low frequency to the required high frequency. In industrial applications, it is known that frequency converters present a large amount of mass and also suffer from the drawback of poor energy efficiency for an induction heating system.